best but approximate; but even these are better than the results from cultures scattered over gelatine surfaces. This method, however, is good as a preliminary, and is in brief as follows: A definite quantity of the suspected water is placed in a measure of nutrient gelatine; this is softened by heat, and the two are thoroughly mixed; and the gelatine is then allowed to harden in a test-tube, or in such a flask as is shown in the figure (fig. 8). The flat, thin surface thus obtained makes it more easy to count the colonies which will appear in a few days. For air-germs, the soluble powder spoken of above is the material to be placed in the nutrient gelatine.

The objections to the method are, that many species of bacteria develop very slowly at the temperature of the air and in a solid medium, and are obscured by other more rapidly growing colonies. The same objections hold in separating the germs in any pathological process.

The method of fractional sterilization used by the Germans is only useful where egg-albumen, or other substances coagulable by heat, are to be employed for culture-media. For this purpose I use a furnace (fig. 9) designed by myself, and manufactured for me by Mr. Wiesnegg. It serves its purpose well, and is much better than that of Koch. It is of double-walled copper, the intervening space being filled with water. This space has openings for thermometer and regulator. The door is double-walled, filled with water, and has its special heater, and it is kept at exactly 75° C. Tubes containing the material to be sterilized are placed in this furnace for one hour daily to kill the full-grown bacteria, and during the rest of the time are kept at 35° C. to favor the growth of the spores. In ten or twelve days the greater part of the tubes will be found to be fully sterilized.

Far better than this is the method of filtering through a substance sufficiently fine to retain all germs, successful results having been long obtained by Pasteur by filtering through plaster. Chamberland's method through porcelain is, however, the best (fig. 10), and is perfectly satisfactory provided the porcelain tube is good. This latter is difficult to obtain. Diluted egg-albumen and blood-serum may be easily filtered in this way, although slowly, under a pressure of from two to three atmospheres. Great care must, of course, be taken, to prevent the contamination of the material after it leaves the canula.

This method of sterilization is peculiarly appropriate for certain animal fluids whose chemical composition is changed by heat, but which it may be necessary to employ as culture-media for certain forms of bacteria.

## *TRANSPORTATION OF PETROLEUM TO THE SEABOARD.*[1]

THE interest in the late project for forcing water for army purposes over the broken and elevated country between Suakin and Berber by means of pipes has called attention to the extent, importance, and utility of the pipe-lines in our own country, which convey the crude petroleum of the region lying between the Alleghanies and Lake Erie to the shores of that lake and the Atlantic seaboard.

The exploitation of these regions by means of artesian wells began about twenty-six years ago. By June, 1862, 495 wells had been sunk near Titusville, and the daily output was nearly 6,000 barrels, selling at the wells at from $4 to $6 a barrel. But as the production increased with rapid strides, the market-price fell with a corresponding rapidity, making the transportation charges to New-York City a considerable proportion of the total cost.

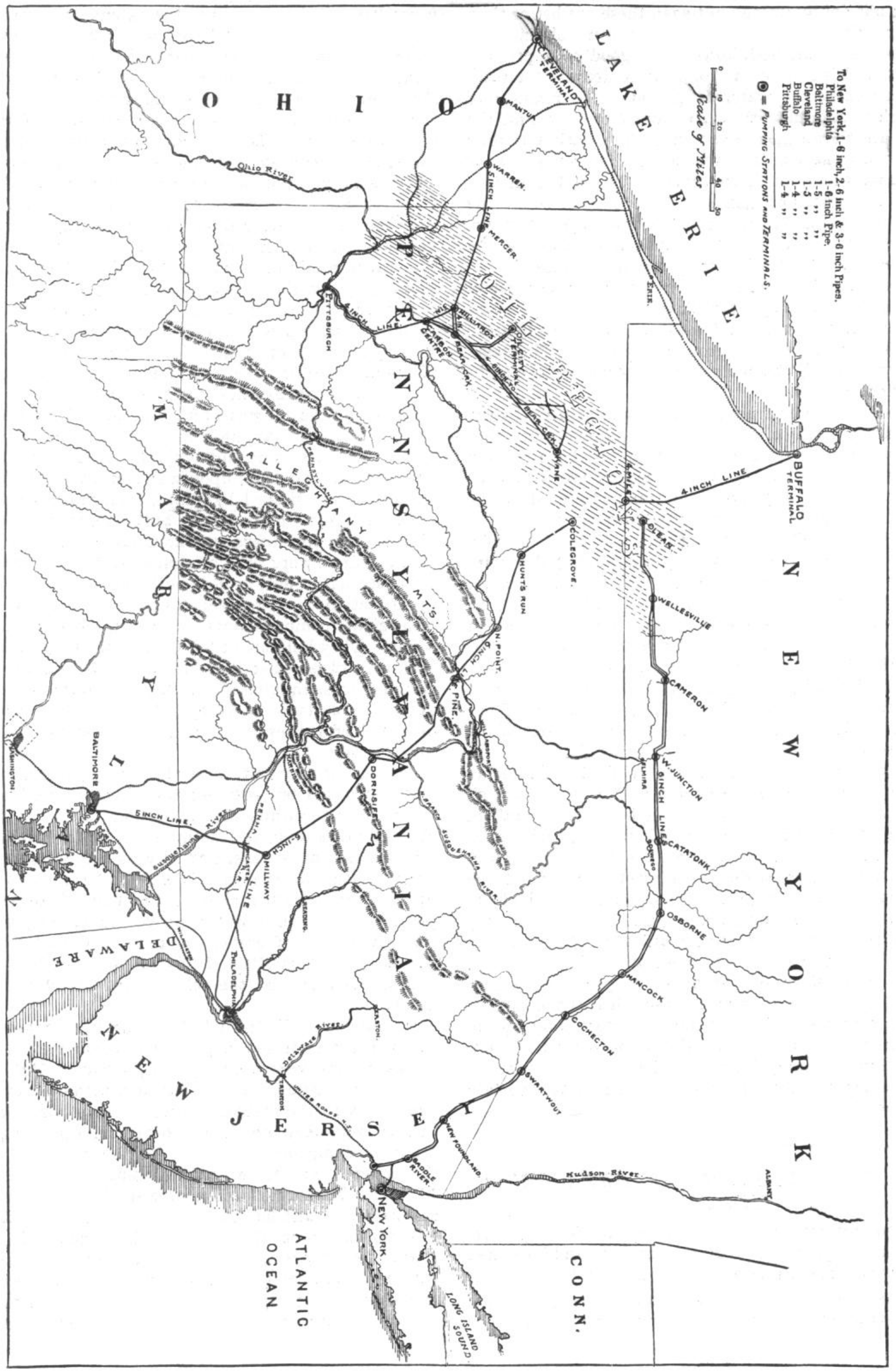
The question of reducing these enormous transportation charges was first broached, apparently, in 1864, when a writer in the *North American* of Philadelphia outlined a scheme for laying a pipe-line down the Allegheny River to Pittsburgh.

Originally the oil was carried in 40 and 42 gallon barrels, made of oak, and hooped with iron: afterward tank-cars were introduced. These were at first ordinary flat cars, upon which were placed two wooden tanks, shaped like tubs, each holding about 2,000 gallons. On the rivers, bulk-barges were also, after a time, introduced on the Ohio and Allegheny. At first these were rude affairs, and often of inadequate strength; but, as now built, they are 130 by 22 by 16 feet in their general dimensions, and divided into eight compartments, with water-tight bulkheads. They hold about 2,200 barrels. In 1871 iron tank-cars superseded those of wood, with tanks of varying sizes, ranging from 3,856 to 5,000 gallons each. These tanks were cylinders 24 feet 6 inches long and 66 inches in diameter, and weighed about 4,500 pounds.

Among the very first, if not the first, pipe-lines laid, was one put down between the Sherman well and the railway terminus on the Miller farm. It was about 3 miles long, and designed by a Mr. Hutchinson: he had an exaggerated idea of the pressure to be exercised, and at intervals of 50 to 100 feet he set up air-chambers 10 inches in diameter. The weak point in this line, however, proved to be the joints. The pipes were of cast-iron; and the joint leakage was so great, that little if any oil ever reached the end of the line, and the scheme was abandoned in despair.

In October, 1865, the Oil transportation company completed and tested a pipe-line 32,000 feet long. Three pumps were used upon it, — two at Pithole, and one at Little Pithole. The first plans to extend such lines to the seaboard seem to have been made in 1876, when the pipe-line owners held a meeting to organize a pipe-line company for this purpose; but the scheme was never carried out. In January, 1878, the Producers' union organized for a similar seaboard line, and laid pipes; but they never reached the sea, stopping their line at Tamanend, Penn. About four years ago the National transit company was organized, and succeeded to the properties of the American transit company. Its lines, illustrated on the accompanying map, were completed in 1880–

[1] Abstract of an article in the *Engineering news* of last week, from advance sheets furnished by the courtesy of the editor.




MAP SHOWING PIPE-LINES OF THE NATIONAL TRANSIT COMPANY. (*Engineering news.*)

81; and this company, to which the United pipe-lines have also been transferred, is said to have $15,000,000 invested in plant for the transport of oil to tide water. They operate a total of 880 miles of main pipe-line alone, ranging from 4 inches to 6 inches in diameter; or, adding the duplicate pipes on the Olean New-York line, we have a round total of 1,330 miles, not including loops and shorter branches, and the immense network of the pipes in the oil regions proper.

A general description of the longest line will practically suffice for all, as they differ only in diameter of pipe used, and power of the pumping-plant. As shown on the map, this long line starts at Olean, near the southern boundary of New-York state, and proceeds by the route indicated to tide water at Bayonne, N.J., and by a branch under the North and East River, and across the upper end of New-York City to the Long-Island refineries. This last-named pipe is of unusual strength, and passes through Central Park. The following table gives the various pumping-stations on this Olean New-York line, and some data relating to distances between stations and elevations overcome: —

| Pumping-stations. | Miles between stations. | Elevation above tide. | Greatest summit between stations. |
|---|---|---|---|
| | | Feet. | Feet. |
| Olean | – | 1,490 | – |
| Wellsville | 28.20 | 1,510 | 2,490 |
| Cameron | 27.91 | 1,042 | 2,530 |
| West Junction | 29.70 | 911 | 1,917 |
| Catatonk | 27.37 | 869 | 1,768 |
| Osborne | 27.99 | 1,092 | 1,539 |
| Hancock | 29.86 | 922 | 1,873 |
| Cohecton | 26.22 | 748 | 1,854 |
| Swartwout | 28.94 | 475 | 1,478 |
| Newfoundland | 29.00 | 768 | 1,405 |
| Saddle River | 28.77 | 35 | 398 |

On this line two 6-inch pipes are laid the entire length, and a third 6-inch pipe runs between Wellsville and Cameron, and about halfway between each of the other stations, 'looped' around them. The pipe used for the transportation of oil is especially manufactured of wrought-iron to withstand the great strain to which it will be subjected. The pipe is made in lengths of 18 feet, and these pieces are connected by threaded ends and strong sleeves. The pipe-thread and sleeves used on the ordinary steam and water pipe are not strong enough for the duty demanded of the oil-pipe. Up to 1877, the largest pipe used on the oil-lines was 4-inch, with the usual steam thread; but the joints leaked under the pressure, 1,200 pounds to the square inch being the maximum the pipe would stand. This trouble has been remedied by the pipe of the present day, which is tested at the mill to 1,500 pounds' pressure, while the average duty required is 1,200 pounds. As the iron used in the manufacture of this line-pipe will average a tensile test strain of 55,000 pounds per square inch, the safety factor is about one-sixth.

The line-pipe is laid between the stations in the ordinary manner, excepting that great care is exercised in perfecting the joints. No expansion joints or other special appliances of like nature are used on the line, so far as we can learn; the variations in temperature being compensated for, in exposed locations, by laying the pipe in long horizontal curves. The usual depth below the surface is about 3 feet, though in some portions of the route the pipe lies for miles exposed directly upon the surface. As the oil pumped is crude oil, and this, as it comes from the wells, carries with it a considerable proportion of brine, freezing in the pipes is not to be apprehended. The oil, however, does thicken in very cold weather, and the temperature has a considerable influence on the delivery.

A very ingenious patented device is used for cleaning out the pipes, and by it the delivery is said to have been increased in certain localities fifty per cent. This is a stem about 2½ feet long, having at its front end a diaphragm made of wings which can fold on each other, and thus enable it to pass an obstruction it cannot remove. This machine carries a set of steel scrapers somewhat like those used in cleaning boilers. The device is put into the pipe, and propelled by the pressure transmitted from the pumps from one station to another. Relays of men follow the scraper by the noise it makes as it goes through the pipe, one party taking up the pursuit as the other is exhausted. They must never let it get out of their hearing, for, if it stops unnoticed, its location can only again be established by cutting the pipe.

At each station are two iron tanks 90 feet in diameter and 30 feet high. Into these tanks the oil is delivered from the preceding station, and from them the oil is pumped into the tanks at the next station beyond. The pipe system at each station is simple, and by means of the 'loop-lines' before mentioned, the oil can be pumped directly around any station if occasion should require it.

The engines vary in power from 200 to 800 horse-power, according to duty required. They are in continuous use, day and night, and are required to deliver about 15,000 barrels of crude oil per 24 hours, under a pressure equivalent to an elevation of 3,500 feet.

The enterprise has been so far a great engineering success, and the oil delivery is stated on good authority to be within two per cent of the theoretical capacity of the pipes. From a commercial stand-point, the ultimate future of the undertaking will be determined by the lasting qualities of wrought-iron pipe buried in the ground, and subjected to enormous strain. Time alone can answer this question.

## *THE STUDY OF BACTERIA.*

THIS is the best summary of the methods best adapted for bacterial research that has as yet been published. It contains little that is

*Die methoden der bakterien-forschung.* Von Dr. FERDINAND HUEPPE. Wiesbaden, *Kreidel*, 1885. 8+174 p., illustr. 8°.